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Does Unemployment Insurance Crowd out Home Production?*

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Abstract

In this paper, we study the interaction between self insurance and public insurance. In particular, we provide evidence on the relationship between unemployment insurance benefits and home production using the American Time Use Survey (ATUS) and the state-level unemployment insurance data of the U.S. The empirical results suggest that moving to a two times more generous state would decrease time spent on home production about 20% for unemployed. Then we pursue a quantitative assessment using a dynamic competitive equilibrium model in which households do home production as well as market production. The model is able to generate the empirical facts regarding unemployment benefits and home production. The fact that unemployment insurance benefits crowd out home production is interpreted as a substitution between the two insurance mechanisms against loss of earnings during unemployment spells.

J.E.L. Classification: D13, D91, E21, J65.

Keywords: Unemployment insurance, home production, public insurance, self insurance, heterogeneous agents models.

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1 Introduction

This paper investigates whether households substitute public insurance (unemployment benefits) for self insurance (home production) against loss of earnings during unemployment spells. We do so in three steps. First, we present a static model to develop an intuition regarding the substitutability between different channels of insurance. Second, motivated by the results of the static model, we provide empirical evidence on the relationship between the level of unemployment insurance and home production using the American Time Use Survey (ATUS) and the state-level unemployment insurance data. Third, we pursue a quantitative assessment on the documented empirical facts using a dynamic heterogenous-agents model of unemployment with incomplete asset markets.

Although there is a vast literature on the effects of unemployment insurance policies on market production, surprisingly there is lack of theory and evidence on the effects of unemployment benefits on non-market production (in particular, home production).[1] Recent studies provided evidence on the use of home production as a self insurance mechanism against lost/reduced earnings.[2] Since unemployment benefit programs provide another channel of insurance against lost earnings, we would like to investigate whether people tend to substitute these two insurance mechanisms.

In doing so, we initially formulate the problem of unemployed agents in terms of income and time allocations in a single period. They are assumed to enjoy consuming goods and leisure. They are able to produce home consumption goods (home production) by combining time and market inputs. Their composite consumption is a combination of home produced consumption goods and market produced consumption goods. They receive unemployment benefits, which they allocate to either market produced consump-

[1] See Krueger and Meyer 2002 for a detailed survey on the labor supply effects of social benefit programs.

[2] Aguiar and Hurst 2005 document that households increase home production at retirement. Burda and Hammermesh 2010 and Taskin 2011 document that households increase home production during unemployment spells

tion goods or market inputs of home production. They allocate their time to either leisure or home production. Optimality implies that agents tend to spend less time for home production as they receive higher amounts of unemployment benefits, i.e. they substitute self insurance with public insurance.

We then use the American Time Use Survey (ATUS) and American state-level unemployment insurance data to provide empirical evidence on the relationship between home production and the level of unemployment insurance. The empirical results suggest a negative relationship between the later and the former. In particular, moving to a two times more generous state would - on average - decrease time spent on home production about 20% for unemployed. Moreover, we investigate a stronger relationship between these two insurance channels (unemployment benefits and home production) for those who have less additional insurance opportunities; in particular, single households respond more strongly compared to the entire sample and household that are married with a non-employed spouse respond more strongly compared to those married with an employed spouse.

In order to pursue a quantitative assessment on the substitution between home production and unemployment insurance benefits, we present a dynamic model featuring a heterogeneous agent framework, where households receive idiosyncratic employment shocks. The asset markets are incomplete in which households can partially insure themselves through a non-interest bearing asset. An additional channel of partial insurance is home production, that is households can increase their home production to insure against lost earnings during unemployment spells. The model implies a reduction in average hours of home production in response to the increased levels of unemployment insurance. In particular, the average fraction of time spent on home production for unemployed is decreasing from .17 to .13 as we increase replacement rate from .20 to .90 gradually. This result is consistent with the empirical results and in line with the interpretation of substitutability between self-insurance (home production) and public insurance (unemployment benefits) against loss of earnings during unemployment spells.

Substitutability between insurance channels has been studied in several papers. For instance, Engen and Gruber (2001) consider precautionary savings as a self insurance mechanism and examine the relationship between unemployment insurance and precautionary savings. They find that households increase their precautionary savings in response to a decrease in unemployment insurance benefits. They interpret this as a substitution between self insurance and public insurance. Cullen and Gruber (2000) consider spousal labor supply as a self insurance mechanism against loss of earnings during unemployment spells. They find that unemployment insurance crowds out this kind of family-insurance mechanism. Cutler and Gruber (1996a,1996b) provide empirical evidence on the fact that households substitute public health insurance for the private one using the policy changes in the U.S. in 1980's and 1990's. Chetty and Saez (2010) emphasize the role of informal self insurance mechanisms such as loans from relatives and spousal labor supply - which does not generate moral hazard problem - in determining the optimal level of social insurance. Among others, Golosov and Tsyvinsky (2007), Attanasio and Rios-Rull (2000), Ortigueira and Siassi (2011), and Taskin (2011) study the interaction between self insurance and public insurance and determine the optimal level of the later under availability of various sources of self insurance. A number of papers including Moffit (1985), Meyer (1990), Card and Levine (2000), and Nakajima (2011) study the effect of unemployment insurance policies on labor supply using the U.S. data. We contribute to the literature on the interaction between self and public insurance by studying home production and unemployment benefits in a dynamic competitive equilibrium framework, and providing empirical evidence on the interaction between these two insurance mechanisms.

The rest of the paper is organized as follows: in section 2, we present a simple theoretical model to illustrate an intuition about the substitutability between different types of insurance channels. We provide empirical evidence in section 3. In section 4, we present the full dynamic model and discuss the quantitative results, and we finally conclude in section 5.

2 A Static Model

In this section, we propose a simple theoretical model to provide an intuitive explanation for the relationship between unemployment insurance policies and home production. We consider a static model - a modified version of Greenwood et al. (1991) - where individuals maximize their single-period utility by enjoying consumption and leisure. We assume that individuals can consume two type of goods; namely home goods and market goods. They can spend their income for purchasing market goods or inputs to produce home goods. They can spend their time on leisure or producing goods at home. Therefore, the home good is produced by a combination of individuals' time and market expenditures. We formulate the problem of the individual as follows:

$$
\begin{aligned}
\max_{h,x} u(c,l) \\
s.t. \\
c_m + x = b \\
c_h = f(h,x) \\
c = g(c_m, c_h) \\
h + l = 1
\end{aligned}
$$

where, c_m is market good, c_h is home good, x is amount of income spent on home production inputs, l is leisure, h is time spent for home production, and b is the unemployment benefits. For simplicity, we assume that the only income for the unemployed individuals is unemployment benefits, b.

Let utility, composite good, and home production function be defined as:

$$
\begin{aligned}
u(c,l) = &\quad \phi l \log(c) + (1-\phi)\log(l) &(1)\\
g(c_m, c_h) = &\quad (\alpha c_m^{(\frac{s-1}{s})} + (1-\alpha)c_h^{(\frac{s-1}{s})})^{(1/(\frac{s-1}{s}))} &(2)\\
f(h,x) = &\quad h^{\nu} x^{(1-\nu)} &(3)
\end{aligned}
$$

where, $e \leq 1$, $0 \leq \alpha \leq 1$, $0 \leq \nu \leq 1$, $0 \leq \phi \leq 1$.

The individual makes time allocation and expenditure allocation decisions to maximize his/her single-period utility. We obtain the optimality conditions with respect to h and x are as follows:

$$
\frac{\phi\nu(1-\alpha)x^{(1-v)(\frac{s-1}{s})}h^{v(\frac{s-1}{s})-1}}{\alpha(b-x)^{(\frac{s-1}{s})} + (1-\alpha)(h^{\nu}x^{1-\nu})^{(\frac{s-1}{s})}} = \quad \frac{1-\phi}{1-h} \tag{4}
$$

$$
(1-\nu)(1-\alpha)h^{v(\frac{s-1}{s})}x^{(1-\nu)(\frac{s-1}{s})-1} = \quad \alpha(b-x)^{((\frac{s-1}{s})-1)} \tag{5}
$$

In above equations, parameter s represents household's willingness to substitute home goods and market goods. Greater s implies a greater substitutability between home and market goods.

We follow optimality conditions 4 and 5 in order to understand the response of h and x with respect to the changes in b. Note that the optimal h and x depend on the substitutability between market goods and home goods (s).

Optimality condition 4 equates the marginal benefit (MB from now on) of h, which is expressed on the left hand side (LHS from now on), to the marginal cost (MC from now on) of h, which is presented on the right hand side (RHS, from now on). MB of an increment in h is reflected as an increase in home goods due to the increase in h multiplied by the utility from each additional unit of home goods. MC of an increment in h is reflected as the foregone utility from decreased leisure due to the increased h. The effect of a change in b on the optimal level of h depends on two effects: one is a direct effect of a change in b, and the other is an indirect effect through x. They affect the optimal level of h in opposite directions and the dominant one is determined by the value of substitutability between home goods and market goods, s.

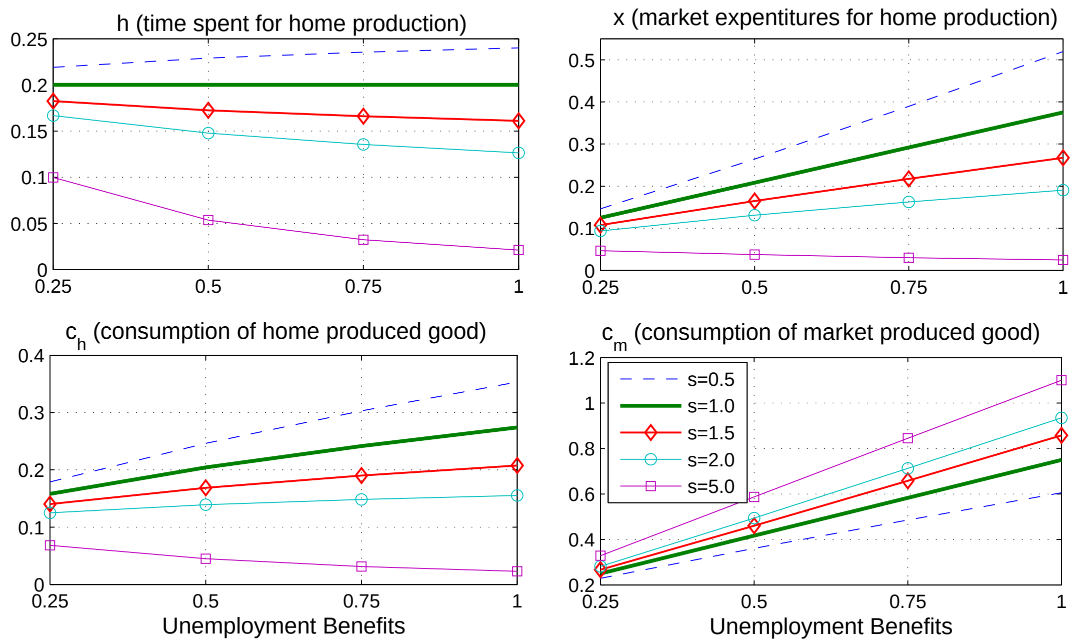
The direct effect of an increase in b on the optimal value of h is derived as follows: according to equation (4), the MB of h is negatively related to the level of b. Therefore, keeping everything else constant, an increase in b implies a downward movement in the optimal level of h. Moreover, the size of the direct effect of increased b on the optimal value of h is bigger for the greater values of s.

The intuition behind the direct effect is the following: when b is increased, the composite consumption is increased and MB from additional consumption units decrease, therefore MB from additional units of home goods decrease as well.[3] Since the MB of h is determined by the utility from increased home goods, the MB of h decreases. As a result, households tend to prefer less h and enjoy more leisure upon an increase in b.

The indirect effect of an increase in b on the optimal value of h is derived as follows: the MB of h is positively related to the level of x. Therefore, the change in the optimal level of x in response to an increase in b affects the optimal value of h as well. Equation (5) determines the optimal level of x, where MB (LHS) is represented by the utility derived from increase in home goods due to the increase in x, and MC

[3]Because this is a static model, an increase in income trivially causes to an increase in consumption.

Figure 1: Static Model: Comparative Statics



Notes: The figure illustrates the responses of optimal decisions (h, x, c_h, c_m) to changes in the level of unemployment insurance. Greater values of s indicate stronger substitutability between home goods and market goods. The values of the rest of the parameters are fixed to the numbers used in Greenwood et al. 1991.

(RHS) is represented by the foregone utility from the decreased market goods (c_m) due to the increase in x. According to equation (5), MC of x is negatively related and MB is invariant to the level of b. Therefore, an increase in b has a positive effect on the optimal value of x. Recall that increased x has a positive effect on the MB of h, which leads to an increase in h. Moreover, the size of this effect is smaller for the greater values of s (RHS of equation 5).

To sum up the two opposing effect: the direct (indirect) effect of an increase in b on the optimal value of h is negative (positive) and increasing (decreasing) with s. Therefore, a threshold level $\bar{s}$ equates these two effects. If s is greater (smaller) than $\bar{s}$, the optimal value of h decreases (increases), otherwise optimal value of h is invariant to an increase in b.

Figure 1 summarizes the above discussion. The figure depicts the optimal allocations of the household for various values of b and s. [4] Panels (a) and (b) depict the optimal levels of h and x. As shown in panel (a), optimal h is decreasing with b when the degree of substitutability between home goods and market goods (s) is greater than a threshold value, 1. If s is equal to 1, optimal h does not respond to the changes in b. If s is smaller than the threshold value, then optimal h is increasing with b. These are illustrated in panel (a) of Figure 1 and clarify the net effect on the optimal value of h.

Panel (b) shows the effect of an increase in b on the optimal value of x. This is critical because a change in x affects the MB of h, therefore b affects the optimal value of h through x. The optimal value of x is increasing with the value of b and the rate of increase is smaller when s is greater. Therefore the indirect effect of b - through x - on h is positive in general, and weaker when s is greater.

Panels (c) and (d) of Figure 1 show the implied allocation of home goods (c_h) and market goods (c_m). When the two goods are weakly substitutable, the response of the

[4] The rest of the parameters are fixed to the values reported in Greenwood et al. 1991.

optimal levels of the two goods are similar to an increase in b. When they are strongly substitutable, c_m absorbs most of the increase in b following the movements in optimal values of h and x (panels (a) and (b)).

Following the empirically plausible values of the elasticity of substitution (1.5 to 2.5) between home and market goods (s), we can conclude that the model implies a negative relationship between the level of unemployment benefits (b) and the time devoted for home production (h).[5]

3 Empirical Evidence

Motivated by the results of the theoretical model in the previous section, we provide empirical evidence on the relationship between the level of unemployment insurance and home production in this section.

3.1 Data

We use the 2003-2008 periods of American Time Use Survey (ATUS) and state-level unemployment insurance data for the corresponding period to carry out the empirical exercise. ATUS is a supplement to Current Population Survey (CPS) and conducted by the U.S. Census Bureau. Respondents report their daily time allocation on various (about 400) activities.

The activities that are used for production of goods and services at home instead of purchasing from market are considered as home production. We aggregate the fraction of time devoted to the corresponding activities to measure time spent on home production. The activities are reported in minutes at daily scale. We rescale them by multiplying with

[5] See McGrattan et al (1997), Chang and Schorfheide (2003) and Aguiar and Hurst (2007) for the values of the aforementioned elasticity.

Table 1: Descriptive Statistics

Group	# of Obs.	% Freq.	Mean HP
Full Sample	65,978	100.00	14.14
Employed	50,444	76.46	12.68
Unemployed	2,580	3.91	18.82
Long Spell	2,178	84.42	18.85
Short Spell	402	15.58	18.63
Single	1,447	56.09	16.15
Married	1,133	43.91	22.21
Female	1,521	58.95	20.62
Male	1,059	41.05	16.23
Not in Labor Force	12,954	19.63	18.89

Notes: The sample includes individuals at ages between 20-65. Data source: Bureau of Labor Statistics (ATUS).

7/60 to get weekly hours. Table 1 presents the descriptive statistics for home production in the ATUS.

In ATUS, individuals report their labor force status in five categories: working, absent, unemployed and looking for jobs, temporarily laid off, not in labor force. The first two groups are considered employed, the second two groups are considered unemployed, and the last group is considered inactive agents. Table 1 reports the number of observations in each group.

We use the differences in unemployment insurance policies across states to analyze the effect of the amount of unemployment insurance on the time spent for home production. In general, the states target to make a payment equal to 50% of lost earnings as the unemployment benefits. However, the state policies display variation with respect to their maximum insurance payments, and we exploit this variation to execute our empirical analysis. The unemployment insurance data and the ATUS are obtained from the U.S. Bureau of Labor Statistics. Table 5 shows the state dependent maximum weekly unemployment insurance payments and the dispersion across states.

3.2 Unemployment Insurance Policies and Home Production

We estimate two alternative equations to test a possible relationship between unemployment insurance policies and home production.

Alternative 1: In this method, we restrict the sample to the unemployed households and estimate the following equation:

$$\log\left(HP_{ist}\right) = \alpha + \beta X_i + \gamma \log\left(wmb_{ist}\right) + \epsilon_{ist} \tag{6}$$

where, HP_{ist} is the weekly hours spent on home production of individual i in state s at time t. X_i is a set of explanatory variables including age and its square, educational attaintment and its square, family size, race dummies, gender dummy, marital status dummy, and year dummies. Weekly maximum unemployment benefit that individual i can have in state s at time t is denoted with wmb_{ist}.

We pool the repeated ATUS cross sections of 2003 to 2008 and estimate equation (6) twice; once with the entire sample of unemployed, and once with those who are unemployed for less than or equal to 26 weeks. The purpose of this specification is to predict the individuals who are eligible for unemployment insurance. Since the maximum duration of unemployment benefits is 26 weeks (exceptions Massachusetts: 30 weeks, Montana: 28 weeks, and Washington: 30 weeks), we use 26 weeks as a threshold value for categorization of the sub-samples.[6]

We are interested in the estimated coefficient of γ in equation (6). Panel (a) of Table 2 presents the estimated coefficient of γ for short-term unemployed agents.[7] The corresponding value is -0.22 and statistically significant for this sample (first column).

[6]Here, we would like to point out that these durations reflect the long-run averages. The duration of payments usually increase in recessions and decrease to the long-run values upon economic recoveries.

[7]Recall that we estimate equation (6) for this sub-group of unemployed in order to proxy those who are eligible for unemployment benefits.

Table 2: Home Production and Unemployment Benefits in ATUS: Only Unemployed

Panel (a): Short Term Unemployed
(unemployment duration≤26 weeks)

	All	Single	Married w/ Employed	Married w/ Non-employed
$\hat{\gamma}$	-0.220*	-0.452**	0.037	-0.359
	(0.111)	(0.222)	(0.145)	(0.330)
Observations	1937	905	808	224
R^2	0.103	0.109	0.071	0.116

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$

Panel (b): All Unemployed

	All	Single	Married w/ Employed	Married w/ Non-employed
$\hat{\gamma}$	-0.192*	-0.415*	0.028	-0.236
	(0.113)	(0.229)	(0.127)	(0.320)
Observations	2191	1051	895	245
R^2	0.101	0.106	0.058	0.102

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$

The interpretation is that moving to a two times more generous state would - on average - decrease the time devoted for home production about 22% for an unemployed household.

We also divide the short-term unemployed agents to three sub-groups: single, married with an employed spouse, and married with a non-employed spouse. The second, third and the fourth columns of Table 2 present the estimated coefficient of γ for those sub-groups. The purpose of this exercise is to understand the role of household composition on the results. The estimated coefficient for single agents is -0.452 and statistically significant. For those who are married with an employed spouse and those who are married with a non-employed spouse, the estimated coefficients are 0.037 and -0.359, respectively.

Panel (b) of Table 2 reports the results for the entire sample of unemployed (instead of only short-term unemployed). The estimated coefficients are slightly smaller than those for the short-term unemployed. This is a very intuitive result, because one would expect a greater coefficient for those who are more likely to be eligible for unemployment benefits. Also, the estimated coefficients for the aforementioned sub-groups (single, married w/ an employed, married w/ a non-employed) are ordered similarly with those estimated using short-term unemployed.

Alternative 2: In this alternative, we include the entire set of workers to the sample instead of restricting to the unemployed. In particular, we estimate the following equation:

$$\log HP_{ist} = \alpha + \beta X_i + \theta U_i + \gamma \log\left(wmb_{st}\right) \times U_i + \psi X_s + \epsilon_{ist} \tag{7}$$

where, X_i represents a set of demographic variables, U_i is an unemployment dummy variable, $\log\left(wmb_{st}\right) \times U_i$ is the interaction between benefits and unemployment, and X_s is a set of dummy variables for each state. We are interested in the estimated coefficient of γ in equation (7).

We estimate the equation twice; once where U_i represents only short-term unemployed (26 weeks or less), and once where it represents the entire set of unemployed. Panels (a) and (b) of Table 3 present the corresponding results. The estimated coefficients are very close to the ones estimated using equation (6), in which only unemployed were included in estimation. Also, the order of the coefficients estimated for the aforementioned subgroups (all, single, married w/ an employed spouse, married w/ a non-employed) are similar to the order of those estimated using only unemployed.

Interpretation: We would like to elaborate on interpretation of three interesting empirical results which are robust to both of the alternative estimated equations: i-)

Table 3: Home Production and Unemployment Benefits in ATUS: All workers

Panel (a): U_i: short term unemployed

	All	Single	Married w/ Employed	Married w/ Non-employed
$\hat{\gamma}$	-0.188	-0.368*	0.015	-0.198
	(0.137)	(0.222)	(0.184)	(0.310)
Observations	52838	18920	26924	6994
R^2	0.076	0.059	0.071	0.097

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

Panel (b): U_i: all unemployed

	All	Single	Married w/ Employed	Married w/ Non-employed
$\hat{\gamma}$	-0.153	-0.329	0.029	-0.136
	(0.130)	(0.216)	(0.168)	(0.302)
Observations	52838	18920	26924	6994
R^2	0.077	0.060	0.072	0.098

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

the estimated coefficients of γ for single agents are greater than those for the entire sample, ii-) the estimated coefficients of γ for the sub-sample of agents who are married with a non-employed spouse are greater than those for the sub-sample of agents who are married with an employed spouse, iii-) for any given sub-group, the relationship between unemployment benefits and home production is stronger for the short-term unemployed compared to all unemployed.

These three results can be explained intuitively within the context of substitutability between different kind of insurance options. First, a single unemployed individual can maintain his/her consumption through either increasing his/her home production or spending unemployment benefits. Therefore the substitutability between these two channels is supposed to be stronger compared to an individual with more insurance options such as spousal income or spousal home production. Since the substitutability is high between home production and unemployment insurance for a single household, home production decreases strongly when unemployment insurance increases. That is, $\hat{\gamma}$ is greater for single households compared to all households. Second, a household with an employed spouse can use the income of the spouse as a self insurance against loss of earnings during unemployment spells. Therefore, one would expect a lower substitutability between unemployment benefits and home production which would imply a smaller $\hat{\gamma}$ for those households. Third, one would expect a stronger relationship between the level of unemployment benefits and home production for those who are more likely to be eligible for unemployment benefits. Therefore, the estimated coefficient of γ is greater for the short-term unemployed households. The estimated coefficients in Tables 2 and 3 are consistent with this interpretation.

4 Full Model

In this section, we study a realistic dynamic model to quantitatively asses the relationship between unemployment insurance benefits and home production. We do so by extending the model of Hansen and İmrohoroğlu (1992) with a home production technology. In general, the model features a heterogeneous agents framework with incomplete asset markets. The details are explained in the following subsections.

4.1 Household Preferences and Constraints

The population consists of a continuum of ex-ante identical agents. There is ex-post heterogeneity in the society due to the fact that the agents receive idiosyncratic employment-unemployment shocks. The idiosyncratic shocks follow a two-state Markov process. In particular, the transition probabilities are defined as $\chi(i,j) = P(e' = j|e = i)$, where

$i, j \in \{0, 1\}$, where e represents the employment status which equals 1 if the individual is employed, and 0 otherwise.

The agents enjoy utility from consumption good and leisure, and maximize their life-time expected utility:

$$E \sum_{t=0}^{\infty} \beta^t u(c_t, l_t)$$

where $u(\cdot)$ is a utility function, β is a time discount factor, c_t is consumption, and l_t is leisure.

The utility function is a Constant Relative Risk Aversion (CRRA) function composed of consumption and leisure with a risk aversion parameter of σ, and the composition of consumption and leisure is formed as a Cobb-Douglas function with a share parameter of ρ:

$$u(c, l) = \frac{c^{1-\sigma} - 1}{1 - \sigma} + \alpha \frac{l^{1-\sigma}}{1 - \sigma}$$

Agents have a time constraint which depends on the employment status:

$$h_t + l_t + n(e) = 1 \tag{8}$$

where h_t is time spent on home production, l_t is leisure and $n(e)$ is labor supply. If an agent is unemployed, then $n(e) = 0$, if he or she is employed, then $n(e) = \bar{n}$, i.e. the labor supply is inelastic and provided in the extensive margin.

The asset markets are incomplete where agents can partially insure themselves through a storage technology (non-interest bearing asset) which evolves as follows:

$$x_t + a_{t+1} = a_t + y_t^d(e) \tag{9}$$

$$0 \leq a_t \tag{10}$$

where x_t represents market expenditures, and a_{t+1} is the amount of wealth carried to the next period. Disposable income (y_t^d) depends on employment status and receipt of unemployment benefits which is explained later on. Equation (10) is a borrowing constraint.

4.2 Home Production

Agents produce consumption goods through home production which combines time and market expenditures:

$$c_t = f(h_t, x_t) \tag{11}$$

where $f(\cdot)$ is a home production function, c_t is the amount of consumption goods and services, h_t is time spent on home production and x_t is market expenditures. In particular, the home production function is a Constant Elasticity of substitution (CES) form as follows:

$$f(h, x) = (\psi h^\nu + x^\nu)^{1/\nu} \tag{12}$$

where, ψ is a home production technology parameter and ν is a parameter which pins down a value for substitutability between time (h) and expenditure (x) inputs of home production, where the elasticity parameter is equal to $\frac{1}{1-\nu}$.

4.3 Unemployment Insurance, Taxation and Disposable Income

An unemployed agent is qualified for unemployment benefits if he/she does not receive a job offer. If he/she is employed or quits a job by his/her own decision or rejects a job offer, then he/she is not qualified for unemployment benefits. Therefore, only involuntarily unemployed agents receive unemployment benefits. The benefits are provided as a certain faction θ of lost earnings, which is called "replacement rate".

The unemployment benefits are financed through proportional earning taxes, denoted with τ. The unemployment benefit system, proportional taxes and the employment process lead to the following disposable income schedule for the agents:

$$\text{gets no offer } (e = 0) \Rightarrow \quad y_t^d = b \tag{13}$$

$$\text{gets an offer } (e = 1),\ \text{accepts} \ \Rightarrow \quad y_t^d = (1 - \tau)y \tag{14}$$

$$\text{gets an offer } (e = 1),\ \text{rejects} \ \Rightarrow \quad y_t^d = 0 \tag{15}$$

where, e represents employment opportunity, y_t^d represents disposable income, y represents wage, and τ represents proportional tax. There is only one type of wage (y) and it is normalized to 1.

The disposable income of an agent equals: (i) unemployment benefits, b, which is payed as a fraction of lost wages θy, if he/she has no job offer; after tax wages, $(1 - \tau)y$, if he/she receives and accepts a job offer; 0, if he/she receives but rejects a job offer. Recall that the agent can also enjoy his/her accumulated wealth in all these three cases.

4.4 Recursive Formulations

In this section, we formulate the problem of agents in recursive form to solve for the equilibrium numerically. An agent with state (a, e) has the following value function formulation:

$$V(a,e) = \begin{cases} \max_{a',h}\{u[f(h, a+(1-\tau)\theta y - a'), 1-h] + \beta \sum_{e'} \chi(0,e')V(a',e')\}, \text{if e=0} \\ \max\{\max_{a',h}\{u[f(h, a+(1-\tau)y - a'), 1-\bar{n}-h] + \beta \sum_{e'} \chi(1,e')V(a',e')\}, \\ \qquad \max_{a',h}\{u[f(h, a-a'), 1-h] + \beta \sum_{e'} \chi(1,e')V(a',e')\}\}, \text{if e=1} \\ \text{s.t. } 0 \leq a' \end{cases} \tag{16}$$

Equation (16) represents the recursive problem of agents where we substituted the time constraint (equation 8), the budget constraint (equation 9), and the home production function (equation 11). In above equation, $u(\cdot)$ is a utility function, a is wealth level, h is time devoted for home production, $f(\cdot)$ is the home production function, τ is a proportional tax on wages, θ is replacement rate, β is discount factor, and e is employment status.

The first line of equation (16) represents the value function of the agent when he/she has no job offer. The second and third lines together represent the value function of the agent when he/she receives a job offer. The agent decides to accept or reject a job offer depending on the corresponding values of those decisions which are presented in the second and the third lines, respectively.

4.5 Equilibrium

We define a *stationary competitive equilibrium* as a set of decision rules of expenditure $x(\omega)$, stock of wealth $a'(\omega)$, home production $h(\omega)$, leisure $l(\omega)$, offer acceptance $\eta(\omega)$, where $\omega = (a, e)$, a tax rate τ, an invariant measure $\lambda(\omega)$ such that;

- the decision rules solve the agent's problem defined in equation (16),
- the goods market clears:

$$\sum_{\omega} \lambda(\omega) x(\omega) = \sum_{\omega} \lambda(\omega) \eta(\omega) y \tag{17}$$

- the government budget is balanced:

$$\sum_{a} \lambda(a, 0)(1 - \tau)\theta y = \sum_{a} \lambda(a, 1)\eta(a, 1) y\tau \tag{18}$$

- and the time-invariant distribution solves:

$$\lambda(\omega') = \sum_{e} \sum_{a \in \Omega} \chi(e, e')\lambda(\omega) \tag{19}$$

  where $\Omega = \{a : a' = a'(a, e)\}$.

Among the equilibrium conditions, equation (17) ensures that the market goods produced by employed agents (RHS) equals the total expenditure of market goods (LHS). Equation (18) equates the taxes collected from employed agents (RHS) to the unemployment benefits payed to the unemployed agents (LHS). Equation (19) ensures that the distribution of the population does not vary over time.

4.6 Calibration

The model parameters are calibrated using the U.S. data. We calibrate the values of the parameters such that the chosen model generated moments are consistent with those of the U.S. data.

Table 4: Parameters of the Benchmark Economy

Parameter		Value
β	Time discount factor	0.995
σ	Risk aversion	2.00
α	Utility, leisure	0.50
n	Constant labor supply	0.45
θ	Benchmark replacement rate	0.40
$\chi(0,0)$	Employment opportunities transition	0.50
$\chi(1,1)$	Employment opportunities transition	0.9681
ψ	Weight of time input in home production (HP)	0.31
ρ	Elasticity of substitution b/w time and market goods	1.45

A model period chosen to be six weeks. The time discount factor (β) is set to 0.995 which is conventional in monthly to quarterly models. Risk aversion parameter (σ) is set to 2, which is standard in the literature. We repeated the quantitative exercises with different values of σ as well. The value of the utility parameter of leisure, which is denoted with α is chosen to match average time spent for home production by unemployed. When we set α equal to .50, average time spent for home production by unemployed is equal to 17.98 hours/week in the benchmark model. The empirical counterpart of this statistics is equal to 18.82 hours/week in the data.[8]

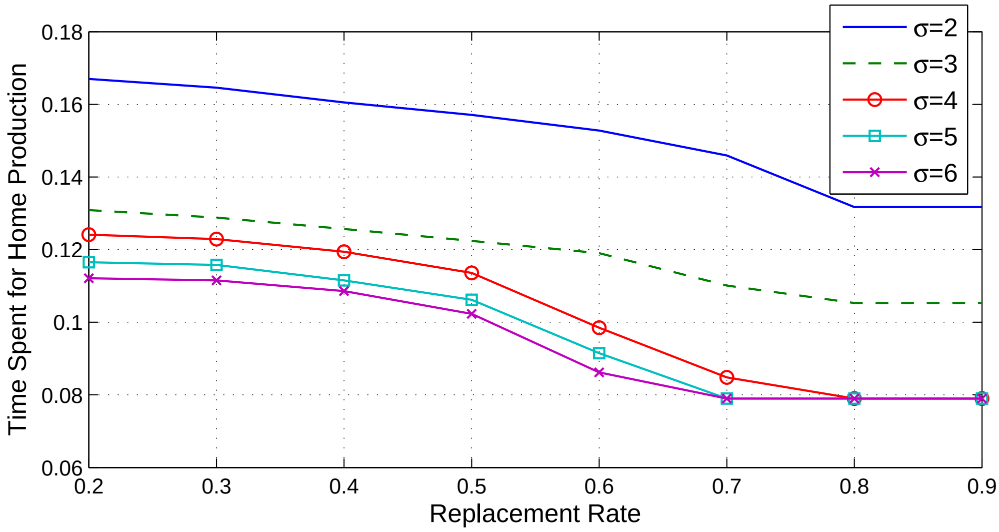
The value of constant labor supply is set to 45% of total available time, which matches average hours of work in the U.S. data. The transition matrix of employment-unemployment states is as follows:

$$\begin{bmatrix} .9681 & .0319 \\ .5 & .5 \end{bmatrix} \tag{20}$$

The above transition matrix matches the long-run rate and average duration of unem-

[8]We use American Time Use Survey to calculate average time spent on home production by unemployed.

Figure 2: Dynamic Model: Replacement Rate vs Home Production



Notes: The figure draws the response of optimal time spent for home production to the changes in replacement rates. Greater values of σ indicate higher degrees of risk aversion.

ployment in the U.S., which are equal to 6% and 12 weeks, respectively. The benchmark replacement rate (θ) is set to be 40% using the estimated values in the empirical literature.[9]

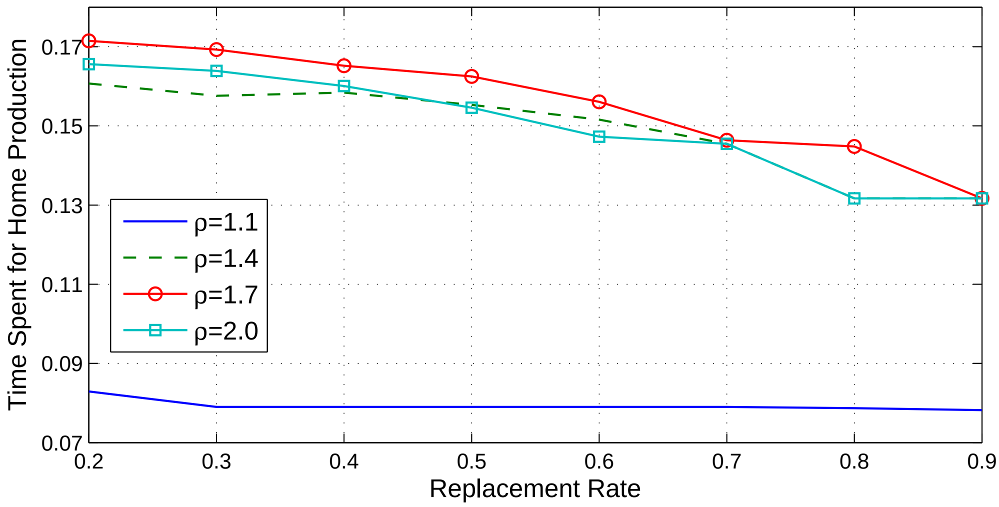
The values of technology (ψ) and elasticity of substitution (ρ) parameters are set to .31 and 1.45, respectively. These values are borrowed from Aguiar and Hurst (2007) where they estimate a home production function using American Time Use Survey. The benchmark values of the parameters are reported in Table 4.

4.7 Quantitative Results

In this section, we present the quantitative results from the dynamic model where we analyze the relationship between unemployment insurance and home production.

[9]Gruber (1997) estimates an average replacement rate of about 40%. Clark and Summers (1982) estimate an average replacement rate of around 65%. In the U.S., replacement rates have decreased over time, and Gruber's work is more recent, therefore we pick the benchmark replacement rate as 40%.

Figure 3: Dynamic Model Cont'd: Replacement Rate vs Home Production



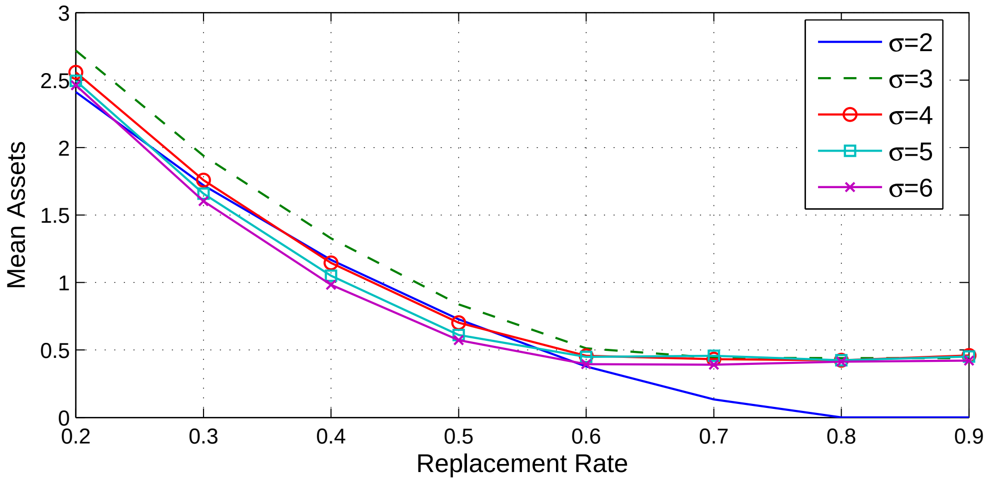
Notes: Greater values of ρ indicate stronger substitutability between time and goods in home production function.

In order to understand the relationship between unemployment benefits and home production, we solve the stationary competitive equilibrium of the model at several replacement rates between 20% and 90%. We compute the average time spent on home production and compare across those stationary equilibria.

In the benchmark model, the average fraction of time spent on home production is decreasing from .17 to .13 as we increase replacement rate from .20 to .90 gradually. These fractions correspond to 18.70 hours/week and 14.75 hours/week. The fact that time spent on home production is decreasing with replacement rate is robust to various degrees of relative risk aversion (σ), which is depicted in Figure 2. This result is consistent with the empirical evidence provided in 3.

Figure 3 depicts the average time spent on home production against the replacement rate at various values of parameter ρ which denotes the elasticity of substitution between time and market goods in home production. The response of time spent on home production gets weaker as the value of parameter ρ takes values smaller than a threshold .

Figure 4: Dynamic Model Cont'd: Replacement Rate vs Mean Assets



Notes: The figure draws the response of optimal savings to the changes in replacement rates. Greater values of σ indicate higher degrees of risk aversion.

This happens because the direct and indirect effects of unemployment benefits on home production neutralizes each other at this threshold level which was explained in detail using a static model in Section 2.

We report the relationship between the rate of unemployment insurance and mean asset holdings by households in Figure 4. The level of asset holdings is decreasing with the rate of unemployment insurance. In particular mean assets decrease from 2.5 to 0.5 as we increase the replacement rate from 20% to 90% gradually. This result is in line with the empirical findings of Engen and Gruber (2001), where they provide evidence on the fact that households substitute self insurance (savings) with public insurance (unemployment benefits). In particular, they report a negative relationship between households' stock of wealth and received unemployment benefits.

In general, the quantitative results can be interpreted within a context of substitutability between self insurance and public insurance. Both savings and home production channels of self insurance are used less intensively in response to an increase in public insurance (unemployment benefits) as shown in Figures 2 and 4.

5 Conclusion

Previous literature provided both theoretical insights and empirical evidence on the effects of unemployment insurance policies on market production. However, the effects of unemployment benefits on non-market production (in particular, home production) have not been studied well. This paper fills this gap by studying the relationship between home production and unemployment insurance policies. Both in the model and the data, we find that higher unemployment benefits are associated with lower home production. This distortion - as well as distortion on market production - should be considered in optimal unemployment insurance policy design.

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6 Tables

Table 5: Weekly Maximum Benefits and Weekly Hours of Home Production

state	2003	2004	2005	2006	2007	2008	Mean wmb	Mean HP
AL	210	210	220	220	230	235	219.13	13.23
AK	320	320	320	320	320	320	320.00	16.62
AZ	205	205	240	240	240	240	226.02	14.16
AR	333	345	345	382	395	409	363.92	13.43
CA	370	370	450	450	450	450	417.84	14.43
CO	390	398	407	421	435	455	415.18	14.83
CT	481	504	522	540	558	576	523.10	14.63
DE	330	330	330	330	330	330	330.00	13.27
DC	309	209	359	359	359	359	327.75	9.90
FL	275	275	275	275	275	275	275.00	13.44
GA	295	300	300	310	320	320	307.66	12.63
HI	371	417	436	459	475	523	438.60	15.09
ID	315	320	325	322	338	364	329.01	14.88
IL	431	438	456	475	498	511	463.68	13.87
IN	312	348	369	390	390	390	362.34	14.74
IA	347	368	381	398	410	426	382.74	14.22
KS	333	351	359	373	386	407	365.04	13.93
KY	329	365	365	365	401	415	367.90	13.38
LA	258	258	258	258	258	258	258.00	14.30
ME	408	438	453	469	480	496	446.32	15.63
MD	310	310	310	340	340	380	331.17	12.82
MA	768	762	778	778	862	900	798.03	14.30
MI	362	362	362	362	362	362	362.00	14.75
MN	427	478	493	515	521	538	487.21	14.20
MS	200	210	210	210	210	210	207.69	12.67
MO	250	250	250	270	280	320	269.62	13.97
MT	286	323	335	346	362	386	333.35	15.58
NE	262	380	288	288	288	298	300.64	15.60
NV	301	317	329	346	362	262	315.97	14.15
NH	372	372	372	372	372	427	380.33	16.77
NJ	475	490	503	521	536	560	508.52	14.10
NM	286	290	350	372	386	455	347.25	17.14
NY	405	405	405	405	405	405	405.00	14.11
NC	396	416	426	442	457	476	430.10	13.52
ND	290	312	324	340	351	385	326.44	11.32
OH	414	436	446	462	479	493	449.61	14.49
OK	304	275	292	317	342	392	319.62	13.83
OR	400	410	419	434	445	463	424.42	15.31
PA	438	469	486	505	528	547	487.81	14.48
RI	518	551	577	596	615	641	569.55	17.86
SC	278	285	292	303	303	326	296.80	12.88
SD	234	248	256	266	274	285	256.05	14.72
TN	275	275	275	275	275	275	275.00	13.58
TX	319	330	336	336	364	378	342.37	13.60
UT	312	377	371	383	406	427	375.13	14.04
VT	351	359	371	385	394	409	373.98	15.60
VA	318	316	326	330	347	363	333.13	13.32
WA	496	496	496	496	496	515	499.21	15.39
WV	351	358	366	380	391	408	373.22	15.50
WI	324	329	329	341	355	355	337.66	15.18
WY	283	306	316	330	349	387	322.40	14.13
Std. Dev. wmb	94.22	96.99	100.51	98.82	107.44	110.12	100.93	1.35
Std. Dev. Log(wmb)	0.24	0.25	0.25	0.25	0.25	0.26	0.25	0.10

Notes: HP and wmb stand for "home production" and "weekly maximum benefit" respectively. Data source: U.S. Department of Labor, Employment and Training Administration. (http://ows.doleta.gov/unemploy/statelaws.asp)